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Synthesis and Characterization of Bimetallic Nanoparticles Loaded with *Chenopodium quinoa* Extract: Assessment of Antibacterial and Cytotoxic Effects

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The rise of multidrug-resistant bacteria and cancer as significant global health issues has intensified the quest for innovative therapeutic agents that are both efficacious and biocompatible. This study prepared copper–silver bimetallic nanoparticles (Cu–Ag BNPs) by an eco-friendly, plant-mediated approach utilizing *Chenopodium quinoa* seed extract as a natural reducing and stabilizing agent. The characterization of the Cu–Ag BNPs validated the effective synthesis. UV–Vis spectroscopy identified distinct plasmonic absorption peaks for both silver and copper, whilst Fourier-transform infrared spectroscopy (FTIR) demonstrated the existence of functional groups from quinoa extract that facilitate reduction and stabilization. Transmission electron microscopy (TEM) revealed primarily spherical nanoparticles with average dimensions in the nanometric range of 40.53nm-91.77 nm, although dynamic light scattering (DLS) indicated a limited size distribution varied from 101.9nm to 176.4 nm and a polydispersity index suggestive of homogeneity. Zeta potential tests varied from –11.6mV to –27.0 mV, indicating considerable colloidal stability. The BNPs exhibited notable antibacterial efficacy against a wide array of ATCC standardized pertinent Gram-positive and Gram-negative pathogens, including *Salmonella typhi, Listeria monocytogenes, Pseudomonas aeruginosa, Acinetobacter baumannii, Acinetobacter johnsonii, Enterococcus faecalis, Serratia marcescens, Escherichia coli, Staphylococcus aureus,* and *Acinetobacter lwoffii* with a zone of inhibition ranging between 15 mm and 19 mm using agar-well diffusion method and OD of 6.13% to 71.4%. Following 24 hours of treatment with BNPs at 100 µg/mL. The BNPs were tested for quorum sensing inhibition using *C.violacium* strain with a zone of 15mm and IC50 of 4.79 µM, indicating that Cu–Ag BNPs can disrupt bacterial communication networks essential for virulence and biofilm development. The MTT test was employed to assess cytotoxicity in human colorectal cancer cell lines HCT-116. The BNPs had a dose-dependent antiproliferative impact, with IC_{50} values of 1.3 ± 0.14 µg/mL for HCT-116. The results indicate that Cu–Ag BNPs produced with Chenopodium quinoa seed extract possess antibacterial, anti-quorum sensing, and cytotoxic properties. Their environmentally friendly production, wide-ranging effectiveness, and biocompatibility render them excellent candidates for future usage in antibacterial and anticancer therapy.